# THE DETERMINATION AND IMPORTANCE OF THE CONDITION OF THE FIRM ALBUMEN IN STUDIES OF EGG-WHITE QUALITY [1]

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## INTRODUCTION

The demand by consumers for eggs of high quality, as shown by market surveys, is reflected in the increasing stress that is being laid on this factor and its measurement in experimental work conducted on poultry. While candling is the basis for establishing the market value of eggs, it is too indefinite to be of more than superficial value in research. Therefore, it has been necessary to study the component parts of the egg. Various investigators have used one or more of the following measurements as criteria of egg quality exclusive of nutritive value: The size of egg; the thickness or strength, porosity, texture, and color of the shell; the color, dimensions, condition, flavor, and odor of the yolk; and the color, relative volume or weight of the various layers of the albumen, and condition of the firm albumen.

The importance of most of these factors has been generally accepted by the majority of investigators. Most workers have used the relative proportions of firm and thin albumen as the sole criterion of albumen quality. The determination of the observed condition, or firmness, of the firm albumen, however, has not received proper recognition. The term "firm albumen" is used throughout this paper to refer to the "true thick albumen" as defined by Sharp (*17*)[3] unless otherwise specifically noted.

It is generally agreed that consumers prefer an egg for table use which holds together well and cooks evenly throughout. The ability of an egg to meet these requirements depends not only upon the quantity of firm albumen but also upon its firmness, body, or condition. There is also the strong probability that this condition of the firm albumen plays an important part in determining the candling properties of the egg, particularly in controlling the apparent mobility, or swing, of the yolk (*10*). On the other hand, Almquist (*1*) has found little correlation between the quantity of firm albumen and the apparent mobility of the yolk. Pennington et al. (*14*) found no relationship between the percentage of thick white and either the candled grade or the yolk index. The reason that no measure of the condition of firm albumen has been generally used in studies of egg quality is undoubtedly that the various physicochemical components which constitute it have not yet been established. However, this is no justification for ignoring an estimation of a factor which plays such

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[3] Reference is made by number (italic) to Literature Cited, p. 1136.

an important part in determining the desirability of eggs from the viewpoint of the consumer and probably of the market man.

The nature of the firm albumen has been subjected to some investigation. It appears unlikely from the work of Almquist and Lorenz (*4*) and of Bronkhorst (*6*) that the difference between firm and thin albumen is entirely chemical. The findings of St. John and Green (*15*) and of Almquist and Lorenz (*3*) strongly suggest that the difference is chiefly a physical one. The latter authors believe that the structure of the firm albumen is due to fibers of ovomucin. Later, McNally (*12*) and Almquist, Givens, and Klose (*2*) showed that the firm albumen contains more ovomucin than the other layers. The findings of the latter authors indicated that photometric methods might be used to detect differences due to the effect, presumably of ovomucin, upon the transmission of light. Such measurements, however, must be correlated with the condition of the firm white as noted by observation. Such an observation necessitates a fixed score capable of reproducible results and of universal application.

A method of scoring the condition of the firm albumen was first used by Sharp (*16*), but he has only recently described and partially illustrated it (*17*). It is the purpose of this paper to illustrate this method more completely, to present further evidence of its importance, and to extend preliminary data presented by the authors (*19*) showing that there is not necessarily a correlation between the condition and the quantity of the firm layer.

## EXPERIMENTAL METHODS

In the first part of this study, photographs were taken to illustrate the score for the condition of the firm albumen. The pictures shown in figure 1 were all taken of freshly laid eggs from pullets of the Cornell strain of Single Comb White Leghorns but represent conditions of the firm albumen encountered in both fresh and held eggs. The scores run from 1.0 to 5.0, as was suggested by Sharp, with intervals of 0.5. In using this method, it was soon found that the scores could be determined accurately by intervals of 0.25. Both top and side (silhouette) views were taken of each egg to illustrate the way the albumen stood up and was distributed around and over the yolk. Each egg illustrates the lower limit for its group range; thus the egg marked 1.0 is the poorest egg that may be scored 1.0. The egg illustrating 5.0 is the lowest score, since no thick albumen is discernible.

The two chief factors in this observation are the outline of the firm albumen viewed from the top, and the outline viewed from the side. The firm albumen in an egg with the best score is concentrated around and over the yolk and tends to occupy the least possible area on the plate. From the top view its outline appears to be ovoid. As the score increases, the firm white spreads and the outline tends to become more irregular. That of 2.5 is generally the first to show this markedly. In this case, a definite tendency toward a rupture of the firm albumen is noticeable. The firm layer of an egg with the score of 3.0 is usually about to rupture, or has just ruptured, allowing the inner thin albumen to mix with the outer thin albumen. From the side view, the outline shows no distinct break in sweep between the yolk and the firm albumen in the best egg. As the score increases, the firm white flattens and spreads out and the angle between the yolk

and albumen appears and becomes sharper until it approaches 90°. This occurs at about the time of rupture of the firm-albumen sac.

The score of the observed condition of the firm albumen considers the apparent thick white described by Sharp (*17*). This includes both the true thick and the inner thin albumen up to the point of rupture of the thick-albumen sac. From this point (score 3.0) on, only the true thick albumen, chiefly structural albumen, is scored since the inner thin layer has escaped.

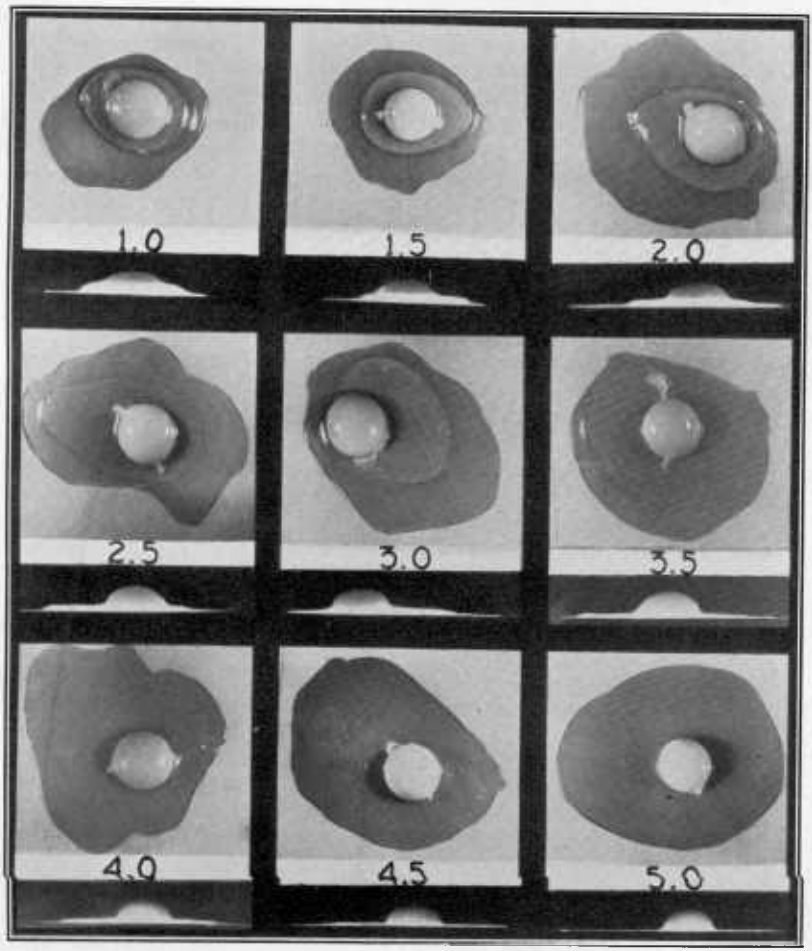


FIGURE 1.—Freshly laid pullet eggs of the Cornell strain of Single Comb White Leghorns scoring 1.0 to 5.0 on the scale suggested by Sharp, showing intervals of 0.5. The eggs shown represent group minima.

In a few instances in which further definition is desirable in exactly placing the score of an egg, the so-called "body" or consistency of the firm albumen may be further determined. This has been done by pouring the firm albumen slowly over the edge of a container and noting its plasticity while retaining the yolk in the container. When quantitative measurements of the albumen are desired, they may be made according to the Sharp (*17*) method of separation by noting the

difficulty with which the firm albumen enters the pipette, or according to the Lorenz and Almquist method (*11*) by noting the apparent plasticity in transferring the egg from the scoring dish to the screen. By observation with candling, using New York State retail grades (*5*), grade Fancy eggs generally score from 1 to 2 when broken out, grade A from 2 to 3, grade B from 3 to 4, and grade C from 4 to 5, but with considerable overlapping.

In the second part of this study, a comparison was made between observed condition of the firm albumen and those factors in candling which would seem to be most closely correlated with albumen condition, in order to determine the relationship between the score for observed condition of the firm albumen and candling quality. A total of 199 eggs was used. These were obtained from several up-State New York City markets and included some fresh eggs from the experiment station flock. Four experienced candlers scored these eggs, and their results were averaged. There was quite regular agreement among the candlers as to the scores for the various factors used. Yolk visibility was scored from 1, for practically invisible yolk shadow, to 4, for a plainly visible yolk shadow. Yolk mobility was scored from 1, for very slight mobility, to 3, for freely mobile yolk shadow. The grades used were from 1 to 8, based upon the New York State retail grades for eggs as described in detail elsewhere (*5*). Eggs were scored as being high or low within each of the New York State grades Fancy, A, B, and C; thus making a complete score of eight grades. No inedible eggs, as detected before the candle, were used. The eggs were opened immediately after candling and were scored for observed condition of the firm albumen and for yolk color as hereinafter described.

In the third part of this investigation, correlations were made between the relative volumes of the three principal layers of albumen obtained as previously briefly described (*19*) and the observed condition of the firm albumen. This was done with data obtained in routine studies in this department on the effect of breeding and feeding upon interior egg quality.

All of the 4,796 eggs studied were from the Cornell strain of Single Comb White Leghorn pullets. All of them were examined on the day that they were laid. Each was carefully broken into a Petri dish, preferably one of 15 cm diameter. If the firm albumen was unruptured, the outer layer of thin albumen was removed into a graduated cylinder by means of a 25-cc pipette. The pipette had a bore of approximately 4 mm, with the tip broken off and the broken end fire-polished. The observed condition of the firm albumen was then noted. Next, this was torn to allow the inner layer of thin albumen to escape. The firm layer was removed from the side opposite the rupture by drawing it into the pipette and was placed in another graduated cylinder. The chalazae and the removable portions of the inner layer of thick albumen, usually very slight, were included in this fraction. Finally, the inner thin layer was removed to a third cylinder. By careful manipulation, accurate and rapid determinations may be made in this manner. The use of moistened cylinders, dishes, and pipettes reduces the error of drainage and speeds up the work.

The yolk was then transferred to a smaller, perfectly flat-bottomed Petri dish for color determination (by the Sharp standards), for yolk-

index measurements (*18*), and, finally, for weight determination. When the firm albumen was found to be in the naturally ruptured state, the observed condition was taken first, and then the firm albumen and finally the combined layers of thin albumen were removed.

## EXPERIMENTAL DATA AND DISCUSSION

The results showing the means and correlations obtained between the candlers' score and the opened egg score of the factors studied are given in table 1. The mean observed condition of these eggs was considerably below that of 1.76 found for fresh eggs as shown in table 2. In every case, a significant positive correlation was found between the observed condition of the firm albumen and the yolk shadow visibility, yolk shadow mobility, and candlers' grade. This, therefore, indicates that the condition of the firm albumen is closely related to those factors used in determining the candling quality of the egg. In contrast to this is the report of Almquist (*1*) that there is no correlation between the quantity of firm albumen and the apparent mobility of the yolk, and the report of Pennington et al. (*14*) that there is no relationship between the quantity of firm albumen and the candled grade.

TABLE 1.—*Correlations between candlers' score and opened-egg score of certain factors*

| Factors correlated | Mean | $r \pm S.E._r$ |
|---|---|---|
| Observed condition of firm albumen | 2.45 | |
| Correlation of observed condition of firm albumen with— | | |
| Yolk visibility (1=none to 4=plainly) | 1.85 | +0.504±0.054 |
| Yolk mobility (1=none to 3=freely) | 1.77 | +.543±.051 |
| Candlers' grade (1 to 8) | 3.66 | +.583±.048 |
| Actual yolk color (00 to 110) sharp standards | 58 | |
| Correlation of actual yolk color with yolk visibility (1=none to 4=plainly) | 1.85 | +.443±.057 |

TABLE 2.—*Correlations between the observed condition of firm albumen and the volume of the various layers of albumen*

| Condition of firm-albumen sac | Eggs | Factors correlated | Mean | $r \pm S.E._r$ |
|---|---|---|---|---|
| | *Number* | | | |
| Not ruptured | 4,531 | Observed condition of firm albumen | 1.76±0.27 | |
| | | Correlation of observed condition of firm albumen with— | | |
| | | True firm albumen, percent | 53.7 | +0.020±0.015 |
| | | Outer thin albumen, do | 24.4 | −.015±.015 |
| | | Inner thin albumen, do | 21.9 | −.006±.015 |
| Ruptured | 265 | Observed condition of firm albumen | 3.38±.47 | |
| | | Correlation of observed condition of firm albumen with— | | |
| | | True firm albumen, percent | 55.2 | −.212±.059 |
| | | Total thin albumen, do | 44.8 | +.178±.059 |
| Do.[1] | 261 | Observed condition of firm albumen | 3.37±.47 | |
| | | Correlation of observed condition of firm albumen with— | | |
| | | True firm albumen, percent | 55.8 | −.061±.062 |
| | | Total thin albumen, do | 44.2 | +.022±.062 |

[1] 4 abnormal eggs eliminated.

It is interesting to note that the correlation between actual yolk color and visibility of the yolk shadow is significant but not as high

as that between condition of firm albumen and visibility of the yolk shadow. Data obtained with this group of eggs support the opinion of some investigators that the firm albumen is probably of as much or more importance in determining visibility of the yolk shadow than is the actual color of the yolk.

The averages and distribution obtained in the third part of this study for the observed condition of the firm albumen and the proportions of the three chief layers of albumen are shown in table 2 and figures 2 and 3, respectively. The proportions of the various layers of albumen are in general agreement with those obtained by Almquist (*1*). The amount of firm albumen, however, is considerably less than that reported by Card and Sloan (*7*) and by North (*13*). It is interesting to note that the amount of firm albumen was slightly greater in the eggs of poor condition in which the firm albumen sac was ruptured. This apparent increase has also been observed, despite a decided increase in score of condition, in eggs from individuals producing eggs of known interior quality which were stored for periods of from 7 to 10 days.

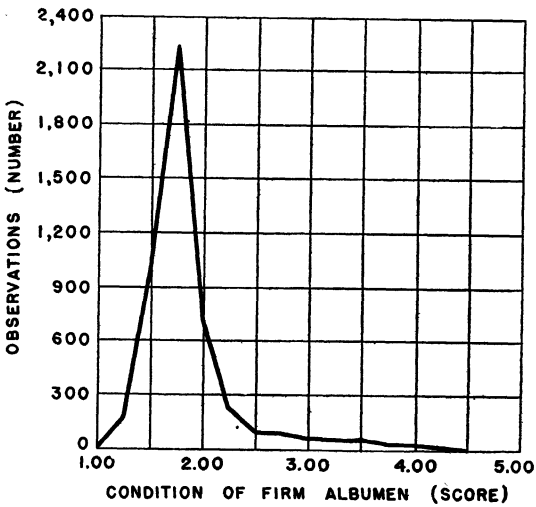


FIGURE 2.—Distribution of the scores for the observed condition of the firm albumen of 4,796 eggs less than 1 day old.

The firm-albumen sac was unruptured in 4,531 of the eggs and permitted the determination of correlations of observed condition of firm albumen with the three main layers of albumen. The results, given in table 2, show that there was not the least correlation between the observed condition of the firm albumen and the proportion of the firm, outer thin, or inner thin layers of albumen.

In the 265 eggs in which this sac was ruptured, the inner thin layer was mixed with the outer thin, hence these eggs could not be included in the larger group. There were slight, though insignificant, correlations between the observed condition of the firm albumen and the proportion of firm albumen and the proportion of total thin albumen, respectively. These slight trends, however, were due to four eggs which possessed an abnormally small amount, or in one case, none, of the firm albumen, and correspondingly large amounts of thin albumen. With these extraordinary observations eliminated, no correlations existed (table 2).

These data present conclusive evidence that the proportion of true firm albumen, used by many investigators as the sole criterion of

albumen quality, is actually in no way related to the firmness, or condition, of the firm albumen. Furthermore, the proportion of inner or outer thin albumen is likewise no indication of the condition of the firm layer.

These findings are in general agreement with the observations of Sharp (*17*) on storage eggs. The two studies cannot be directly compared, however, since he used what he called "apparent thick white", whereas the present study refers to what he defined as "true thick white." The fact that the score of the observed condition of the firm albumen decreases during storage (*8*) and the amount of firm albumen also decreases (*9*) during storage indicates that a correlation should be found between the observed condition and the proportion of the firm albumen of eggs subjected to any considerable period of storage.

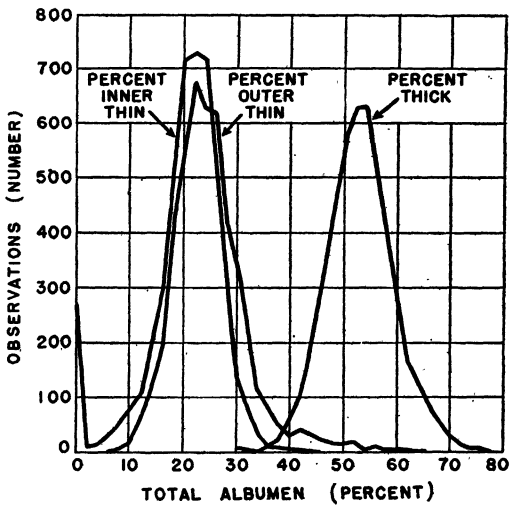


FIGURE 3.—Proportions of the 3 main layers of albumen in 4,796 eggs less than 1 day old.

If the findings of Almquist and Lorenz (*3*), that the firmness of the firm albumen is due to the presence of ovomucin, and those of McNally (*12*), that the firm albumen contains considerably more ovomucin than the thin albumen, are substantiated, the quantitative determination of ovomucin might be used as a more exact measure of the condition of this layer of albumen. It has not been shown, however, that the methods of either authors are quantitative or that the amount of ovomucin is related to the quality or the quantity of firm albumen. That they are not quantitative is indicated by the lack of even moderate agreement in their figures. Furthermore, the use of a chemical method is at a distinct disadvantage when compared with a score such as the observed condition, since the large amount of time involved in a chemical analysis prohibits the use of the number of eggs necessary in studies on egg quality.

This score is not proposed to take the place of more accurate means for measuring this condition when they become available. Some measurements of a physical nature are under study here. One of the most promising of these is the height of the apparent firm albumen weighted for the size of egg and expressed in terms of a 2-ounce egg. The score does, however, offer a valuable aid in studies of egg quality in the interim, and it should supplement such measurements as they become available, since it scores the sum of the factors which constitute albumen quality as seen by the consumer.

## SUMMARY

A method for determining the observed condition of the firm albumen of eggs is illustrated. Significant correlations were found between the observed condition of the firm albumen and the visibility and the mobility of the yolk shadow, respectively. Thus, as the yolk shadow appeared more visible and mobile in candling, the score of the condition of the firm albumen was poorer. No correlation was found between the observed condition and the percentage of true firm albumen in freshly laid eggs. It is therefore necessary to measure the condition as well as the quantity of firm albumen in the egg.


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